MULTIFACTOR PRODUCTIVITYAND SOURCES OF GROWTH IN CHINESE INDUSTRY: 1980-85*

by

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ABSTRACT

This paper examines the economic performance of the Chinese industrial sector in the post-reform period 1980-1985. A multifactor productivity model is used to isolate the contributions of labor, capital, and technical efficiency to growth in industrial output. Using information from the National Industrial Census of China (1988) for large and medium-size enterprises, we find that growth in industrial labor productivity in the post-reform period is attributable to increases in capital intensity not technical efficiency. Moreover, collective and other nonstate enterprises show higher partial labor and multifactor productivity gains than do state enterprises. We also find that multifactor productivity gains are closely tied to increases in retained profits and the proportion of total employees that are technical workers. Surprisingly, labor bonuses have a near zero or negative effect on multifactor productivity growth although this result is not very robust.

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I. Introduction

A striking feature of Chinese economic policy in the past decade is the implementation of various reform measures aimed at improving industrial performance. These reforms followed what many observers term a period of stagnation in industrial productivity.[1] By allowing enterprises to retain a portion of their profits, devolving a greater degree of decision-making to factory managers, permitting material incentives such as bonuses to be reintroduced, drastically reducing the scope of planning, and increasingly relying on markets for interindustry resource allocation, post-1979 reform measures sought to revitalize an economy gripped by inertia.[2]

How successful have these reforms been? Recent studies show that they have been very successful in agriculture.[3] But, in the industrial sector multifactor productivity apparently declined sharply in 1982, four years after the initial reforms in 1978. This decline led Chinese authorities to implement further reforms in 1984.[4]

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[1]See Rawski (1979), Lardy (1983), and Perkins (1988).

[2]These and other reforms are discussed in Tidrick and Chen (1987), Naughton (1986), Byrd (1987), and Wu (1987).

[3]For example, McMillan, Whalley, and Zhu (1989) found that output in the Chinese agricultural sector increased by over 61 percent between 1978 and 1984.

[4]The 1984 reforms focused on the urban or non-farm sectors, see Reynolds (1988).

The purpose of this paper is to examine the economic performance of the Chinese industrial sector in the post-reform period (1980-85). We use the new and most comprehensive data set available on chinese industrial activities, the recently published National Industrial Census of China (1988). These data describe the operations of large and medium-sized enterprises, which account for approximately half of industrial production in China.

Our procedure is to calculate multifactor productivity growth rates for 39 major industrial branches in manufacturing and nonmanufacturing for the 1980-85 period. With these estimates, the sources of observed differences in multifactor productivity growth, are examined. Particular emphasis is placed on incentives and human capital as explanations for multifactor productivity growth.

Several interesting results emerge from the analysis. At the total industry level, the annual growth rate of labor productivity is 7.7 percent for the 1984-85 period compared with 2.8 percent for the 1980-84 period. Of perhaps more interest, 81 percent of this 4.9 percent gain in labor productivity growth is associated with growth in capital intensity. Thus, Chinese industries experienced sharp increases in labor productivity growth in 1984-85 period as compared to the 1980-84 period. This indicates that the economy responded quickly to the 1984 reforms.

The aggregate data hide wide differences in productivity growth rates among industries and types of enterprises. We find that 26 of the 39 industries examined have positive labor productivity growth rates in the 1980-84 period. The number of industries with positive growth rates increases to 30 when 1984-85 is the measurement interval. Of more note, increases in labor productivity growth are uniformly greater for collective and other nonstate enterprises than for state enterprises during both the 1980-84 and 1984-85 periods. This differential performance is attributable to higher rates of growth in both multifactor productivity and capital intensity for the collective and other nonstate firms, especially during the 1984-85 period. This finding is of particular interest because full participation of the state-owned industrial sector in the 1979 reforms was reportedly postponed until 1984 due to concern over inflation generated by excess demand for investment goods in 1981.[5]

Regression analysis is used to determine factors explaining differences in multifactor productivity growth across industries. We find that the proportion of technical employees has significant positive effects on multifactor productivity growth in the Chinese industrial sector. In addition, there is evidence that retained profits have a positive impact on productivity. Somewhat surprisingly, bonus payments to labor have a zero or negative effect on multifactor productivity growth. While this

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[5]See Perkins (1988), and Wu and Reynolds (1988).

result is not particularly robust, if true it would suggest that bonus payments do not improve multifactor growth rates.

The paper is organized into six sections. Section 2 discusses the multifactor productivity growth model. A brief discussion of the data and calculations, is given in Section 3. Section 4 discusses the measures of productivity growth across 39 major branches of Chinese industry. Section 5 examines the sources of multifactor productivity growth across industries and provides evidence on productivity differences by ownership. The final section offers suggestions for further work.

II. Model

The model employed in this study provides a framework for calculating a multifactor productivity measure for each industry. It is widely used to analyze the sources of growth in economic efficiency throughout the world. The use of this index traces to the pioneering work of Solow (1957), and the version of the model we use here is regularly applied in the United States by the U.S. Bureau of Labor Statistics with data collected by various statistical agencies, including the U.S. Bureau of the Census.[6] The multifactor productivity model is also employed in recent studies of the Chinese economy.[7]

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[6]See Mark and Waldorf (1983), and Sherwood (1987).

[7]Kuan, et al (1988), and Jefferson (1988, 1989a, and 1989b).

The conventional methodology for productivity measurement is based on a production function, which can be written in the following general form

$$(1) \quad Q(t) = A(t)f[K(t),L(t)],$$

where $Q(t)$ = real output at time t,

$K(t)$ = capital input at time t,

$L(t)$ = labor input at time t,

$A(t)$ = index of Hicks-neutral technical change or multifactor productivity at time t.

Differentiating (1) with respect to t, and with some algebraic manipulations, we can derive the following basic multifactor productivity growth model

$$(2) \quad \dot{q}(t) = \dot{a}(t) + w_k\dot{k}(t) + w_l\dot{l}$$

where,

$\dot{q}(t) = \dfrac{dQ(t)/dt}{Q(t)}$ = rate of change of output at time t,

$\dot{a}(t) = \dfrac{dA(t)/dt}{A(t)}$ = rate of change in multifactor productivity at time t,

$\dot{k}(t) = \dfrac{dK(t)/dt}{K(t)}$ = rate of change in capital services at time t,

$\dot{l}(t) = \dfrac{dL(t)/dt}{L(t)}$ = rate of change in labor services at time t,

$w_k = \dfrac{dQ(t)}{dK(t)} \dfrac{K(t)}{Q(t)}$ = the weight associated with capital input in period t which is the output elasticity of capital, and

$w_l = \dfrac{dQ(t)}{dL(t)} \dfrac{L(t)}{Q(t)}$ = the weight associated with labor input in period t which is the output elasticity of labor.

Output, labor services and capital services are all measured in real terms in equation (1). The output variable is measured as value added or net output.[8] The multifactor productivity model (2) apportions the growth in real output into changes in production efficiency and changes in inputs.

If constant returns to scale are assumed so that the labor and capital weights sum to 1.00, then equation (2) can be rewritten as

$$(3)\ \hat{q}(t) - l(t) = \hat{a}(t) + w_k\{\hat{k}(t) - l(t)\}.$$

Equation (3) partitions the rate of change in labor productivity, $[\hat{q}(t)-l(t)]$, into the rate of change in multifactor productivity, $\hat{a}(t)$, and the weighted rate of change in the capital-labor ratio, $w_k\ [\hat{k}(t)-l(t)]$. The capital-labor ratio measures the degree of capital intensity. Moreover, if factors are paid according to their marginal product, the weights or output elasticities of the inputs to the production process are equal to the factor shares in total output.[9]

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[8]An alternative formulation is to use gross output and a direct measure of energy and materials in equation (1). Although information on the cost of materials and energy is available from SSB (1988), an adequate price deflator for materials and energy is not available. We saw no reason to adopt the assumption that the rates of increase in output and input prices are similar, a necessary condition for application of the model in the absence of such prices. With some support from aggregate U.S. studies, our approach can be justified if materials and energy are separable inputs to the production process. See Dean and Kunz (1988).

[9]At the economy-wide level equations (1) and (2) can be viewed as a theory of distribution in that the factor shares get the fruits of the production process. Equation (3) assumes that in the long run equilibrium factor payments exhaust the national product. The multifactor productivity measure then becomes a "residual" measuring the extent to which the national product

Many recent studies suggest that the assumption of capital and labor being paid their marginal product in the Chinese economy is false. Of course, this assumption is not perfectly satisfied even for the United States or other "competitive" economies. Violations of this assumption would lead to bias in the estimate of the capital weight, w_k, in equation (3). Lieberman, Lau, and Williams (1989) show that if the output market is not competitive, then income shares tend to underestimate production elasticities.[10] This means that use of the income share of capital may lead to an underestimate of the weighted growth rate of capital intensity.

The 1985 estimates we obtain for Chinese firms' capital share and labor share are 67% and 33%, respectively. (Details of the calculations are outlined in the Appendix.) This capital share is much higher and this labor share much lower than those found for U.S. firms. But, the point should not be overdrawn. The capital share (labor share) of U.S. firms rank with the lowest (highest) in the world. For example, Lieberman, Lau, and Williams (1989) found that the estimated capital and labor shares of U.S. automobile firms are 29% and 71%, respectively. In contrast, the corresponding figures for Japanese automobile firms

growth arises from increases in efficiency not associated with payments for the labor and capital services.

[10] If output markets are not competitive, but input markets are, then it can be shown that cost shares equal production elasticities. We tried the cost share instead of the output share of capital to estimate w_k in equation (3). The results do not alter the general conclusions of this paper.

are 42% and 58%, respectively. In this regard, the low estimate for labor share and high estimate for capital share for Chinese firms is not unreasonable because labor costs in China are substantially lower than those in either Japan and in the United States.

Furthermore, even if the multifactor productivity growth estimate is subject to some upward bias due to errors in the estimate of w_k, its trend shows relatively small errors because the trend is affected by the percentage change, not the level of w_k. Indeed, if w_k is stable and the bias is constant, then it can be shown that the error of the change in multifactor productivity growth equals the bias multiplied by the change in the capital intensive growth. For example, if the bias is 10% and the change in the capital intensity growth is 10%, then the error in the change of total factor productivity equals 1%, which is small. Because the period under study is relatively short, we do not expect substantial changes in the factor shares. Thus, despite the difficulty associated with the estimate of w_k, the multifactor productivity model (3) provides a useful organizing device to characterize the net effect of all those factors other than factor inputs which are important in output growth.[11]

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[11]The multifactor productivity growth measure, $\hat{a}(t)$, sometimes called the "residual," may reflect many factors depending on the particular context in which it is applied. For example, four our data $\hat{a}(t)$ could reflect many things including technical change, or perhaps, measurement errors if our assumption of constant returns to scale is incorrect, or labor is imperfectly measured when total workers is a biased proxy for labor services. In fact, much of the recent literature on

III. Data and Sources

For multifactor productivity analysis, we use data reported in the People Republic of China's National Industrial Census (1988) which covers 39 branches or industries. For each industry, we construct measures of real output, and capital and labor inputs. These derived variables allow us to calculate the growth rates of output and inputs which, in turn, enable us to decompose labor productivity growth into multifactor productivity growth and the growth in capital intensity, using equation (3).

To analyze the sources of productivity growth, we use the estimated multifactor productivity growth obtained from equation (3) as the dependent variable. The exploratory variables include the number of engineers and technical employees, computers, retained profits and bonuses which are directly available in the National Industrial Census.

All data are annual and cover the years 1980, 1984, and 1985. Details on the data and variable measurement are discussed in the Appendix.

IV. Multifactor Productivity Growth

Tables 1 and 2 exhibit the labor productivity growth decomposition of Equation (3) for the periods 1980-84 and 1984-85, respectively. The first column of each table gives the rate

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Chinese productivity consists of explorations of various techniques and data adjustments designed to provide improved estimates of the basic model. In this regard, this paper is no exception.

of growth in labor productivity over the period, and the remaining two columns allocate this growth rate into the rate of growth in multifactor productivity and in the capital-labor ratio. Industries are classified into two sectors: manufacturing and non-manufacturing.

The results shows that labor productivity for both the manufacturing and non-manufacturing sectors increased in the two periods, 1980-84 and 1984-85. However, while labor productivity for manufacturing grew at an increasing rate (from 2.45 percent in 1980-84 to 8.59 percent in 1984-85), that for nonmanufacturing grew at a decreasing rate (from 4.48 percent in 1980-84 to 0.22 percent in 1984-85). In both sectors, labor productivity growth is attributable to the growth in capital intensity as the corresponding growth rates of multifactor productivity are negative.

The total industry data show a higher growth rate in labor productivity in 1984-85 than in 1980-84. Table 3 shows an average annual rate of 2.8 percent for 1980-84 and 7.7 percent for 1984-85. Most of this gain is attributable to an increase in capital intensity as the rate of change in multifactor productivity remains virtually constant between the two periods.[12]

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[12]We emphasize that the negative rates of growth in multifactor productivity illustrated in Tables 1, 2, and 3 do not mean that the <u>level</u> of multifactor productivity is negative. By definition multifactor productivity is always positive. The

Despite the sensitivity of the model estimates to the estimated factor shares, we note again that the conclusions about the trend of multifactor productivity growth are less subject to

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negative rates of growth indicate that, for the periods under consideration, the rate of growth of multifactor productivity declines for some industries and ownership systems.

Table 1. Contributions to Growth of Labor Productivity: 1980-84

Nonmanufacturing

		Labor Productivity Growth	Multifactor Productivity Growth	Growth in Capital/Labor Ratio
1	Coal	-.00397	.13493	-.13890
2	Pet.&Gas	.00815	-.04128	.04943
3	Ferrous	.07710	.01643	.06067
4	Non-Ferr	-.00368	-.06290	.05922
5	Bldg.Mat	.00847	-.03462	.04309
6	Salt	.00122	-.03061	.03183
7	Logging	.01709	-.04608	.06317
8	Water	-.00418	-.07459	.07041
9	Feeds	.42342	.19275	.23067
10	Elect	-.00628	-.05924	.05297
11	Coke	-.02482	-.03649	.01167

Manufacturing

12	Food	-.02589	-.10002	.07413
13	Beverage	.01026	-.11983	.13010
14	Tobacco	.00860	-.13272	.14132
15	Textiles	-.07668	-.15044	.07376
16	Clothing	.04571	-.03069	.07640
17	Leather	-.04591	-.10089	.05498
18	Woodprod	-.00832	.22331	-.23163
19	Furn	.01546	-.03294	.04840
20	Paper	-.00820	-.06154	.05334
21	Printing	.10380	.02522	.07859
22	Culture	.04390	-.03249	.07638
23	Artcraft	-.02698	-.15715	.13017
24	Pet.Ref	.00790	-.08041	.08831
25	Chemical	.03548	-.06374	.09923
26	Medicine	.01996	-.04940	.06936
27	Fibres	.07853	-.01475	.09328
28	Rubber	.00351	-.06682	.07032
29	Plastics	.04866	-.06060	.10925
30	Nonmetal	.02250	-.03132	.05382
31	Ferrous	.03052	-.03161	.06213
32	Non-Ferr	-.00205	-.06083	.05878
33	MetalWk	.02038	-.04358	.06396
34	Eng.Eq	.04837	.00427	.04410
35	Trans.Eq	.07691	.04343	.03348
36	Elec.Eq	.05261	-.01134	.06395
37	Com.Eq	.20171	.12940	.07231
38	Instru	.05989	.01819	.04170
39	Other	-.05492	-.16808	.11317

Means

Nonmanufacturing	.0448	-.0038	.0486
Manufacturing	.0245	-.0413	.0658

Table 2. Contributions to Growth of Labor Productivity: 1984-85

Nonmanufacturing

		Labor Productivity Growth	Multifactor Productivity Growth	Growth in Capital/Labor Ratio
1	Coal	-.08129	-.73493	.65364
2	Pet.&Gas	-.03848	-.03811	-.00037
3	Ferrous	-.09778	-.31584	.21806
4	Non-Ferr	.24066	.22172	.01894
5	Bldg.Mat	-.10486	-.08435	-.02051
6	Salt	-.10180	-.09367	-.00812
7	Logging	-.00626	.06537	-.07162
8	Water	.01618	-.06151	.07769
9	Feeds	.04130	.24046	-.19917
10	Elect	.03254	.02568	.00687
11	Coke	.12438	.07511	.04927

Manufacturing

		Labor Productivity Growth	Multifactor Productivity Growth	Growth in Capital/Labor Ratio
12	Food	.02875	-.04779	.07654
13	Beverage	-.01121	-.14143	.13022
14	Tobacco	.01763	-.12675	.14438
15	Textiles	.07239	-.04188	.11427
16	Clothing	.02201	-.07485	.09686
17	Leather	.03398	-.03661	.07059
18	Woodprod	-.05261	-.09501	.04240
19	Furn	.09828	.02761	.07066
20	Paper	.11084	-.00875	.11959
21	Printing	-.03593	-.12732	.09139
22	Culture	.11189	-.04324	.15513
23	Artcraft	.11907	.03866	.08040
24	Pet.Ref	.03863	-.00136	.03999
25	Chemical	.00382	-.01011	.01393
26	Medicine	.05910	.02809	.03101
27	Fibres	.26874	.25406	.01468
28	Rubber	.06119	.02707	.03412
29	Plastics	.07530	-.24550	.32080
30	Nonmetal	.08983	-.01373	.10357
31	Ferrous	.01525	-.08747	.10272
32	Non-Ferr	.13915	.09094	.04821
33	MetalWk	.12499	.06159	.06340
34	Eng.Eq	.16717	.09573	.07145
35	Trans.Eq	.23355	.15742	.07612
36	Elec.Eq	.21044	.11359	.09685
37	Com.Eq	.21036	.03741	.17295
38	Instru	.13964	.10909	.03055
39	Other	.05429	-.13886	.19315

Means

Nonmanufacturing	.0022	-.0636	.0659
Manufacturing	.0859	-.0071	.0931

Table 3. Productivity Growth Rates by Type of Enterprise

Productivity Growth Measure and Enterprise Type	Period		Increases
Labor Productivity Growth*	1980-84	1984-85	
Total	.028	.077	.049
State	.027	.074	.047
Collectives	.100	.181	.081
Other	.062	.198	.136
Multifactor Productivity Growth*			
Total	-.036	-.027	.009
State	-.037	-.030	.007
Collective	-.011	.026	.037
Other	-.023	.083	.106
Weighted Capital-Labor Ratio Growth*			
Total	.064	.104	.040
State	.064	.104	.040
Collective	.111	.155	.044
Other	.085	.115	.030

*The estimates are based on weighted averages of the individual industries and thus are not equal to the simple averages obtained from the data in Tables 1 and 2.

error because they are affected by the percentage change, not the level of factor shares. As shown in the Appendix, the correlation between the estimated weight in the 1980-84 and 1984-85 periods are quite high.

V. Sources of Multifactor Productivity Growth

Analysis of the sources of economic growth is divided into two parts. First, we look at the effect of enterprise type on observed multifactor productivity growth. In the second part we examine other factors affecting multifactor productivity growth using cross-section analysis at the industry level.

Enterprise Organization

All other things equal, if one type of enterprise exhibits substantially greater productive efficiency than another, then this information provides guidance to policymakers. In light of the recent emphasis on decentralization of economic decision making in China, we expect that collective and other nonstate enterprises would obtain greater growth rates in productivity than those in the state sector. This hypothesis is also supported by the relatively slow adoption of reforms in the state sector noted earlier.

Table 3 shows that collective and other nonstate enterprises have labor productivity growth rates substantially above those of state enterprises in both periods.[13] Furthermore, the collective and other nonstate enterprises outperform the state enterprises in both components of labor productivity growth, capital intensity growth and gains in multifactor productivity.

Increased rates of growth in capital intensity is the major factor explaining the gains in labor productivity growth for both groups. But, the collective and other nonstate sectors show significant increases in multifactor productivity growth rates while the state sector has small increases. Each enterprise type shows increased multifactor productivity growth rates in the 1984-85 interval as compared to the 1980-84 period. However, as shown in the last column of Table 3, collective and other nonstate enterprises have an increase 3 to 10 times greater than that observed for state enterprises. Moreover, multifactor productivity growth is positive in the 1984-85 period for the collective and other nonstate enterprises while the rate of growth in the state sector is negative in both periods. These results indicate that collective and other enterprises are able

[13] State-owned enterprises are very large relative to the other two types. This is the reason the state and total values are nearly identical in Table 5.

to increase their multifactor productivity in the era of economic reforms far better than state-owned firms. In light of the advantages state-owned firms are purported to have, access to state-allocated inputs at low prices, and relatively better manufacturing facilities, these findings are surprising.

Inter-industry Differences

This section examines factors which are systematically linked to observed differences in the estimated multifactor productivity growth rates across industries. The analysis focuses on two types of variables, one representing factors associated with technical progress and the other associated with incentives to individual enterprises. It is important to note that this analysis does not determine causality. For example, the simple regression analysis we use is not able to distinguish between the hypothesis that bonus payments lead to higher multifactor productivity growth and the hypothesis that bonuses are a reward for past productivity.

With this caveat we proceed to the results of regressions involving the rate of multifactor productivity growth as the dependent variable. There are many possible measures which could be used as independent variables. Based on the available data, the proportion of engineers and technical employees to total employment (Eng/L) is introduced as a source of technical progress. Another variable intended to measure technical progress is the number of computers per employee (Comp/L). Two versions of this measure are used, one based on the number of computers used in production and the other on the total number of computers operated. In either case, the number of computers is only available for 1985. Since most computers were installed after 1980, the computer variable measures the growth of this specialized capital during the 1980-85 period.

We use two variables to capture the effects incentive payments have on multifactor productivity growth. The first is the percentage change in retained profits taken as a proportion of capital assets (%Prof/K). The retained profits variable assesses how much of the surplus produced by the enterprise is retained by the enterprise. The second is the percentage change in bonus wages per employee (%B/L). The bonus measure is designed to assess the extent to which labor is paid based on efficiency gains.

Table 4 provides least squares estimates for the parameters of the model. The associated "t" statistics are given in parentheses under each estimated coefficient. While we try many variations of the basic model, only representative results are shown in the table.[14] The first four equations show the

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[14]We note that while the adjusted R^2 may appear low to those unfamiliar with cross-sectional analysis, they are in fact quite similar to those found in other such studies.

regressions of each variable alone on the dependent variable for the entire sample. (There is one less observation for equation 4 since the variable (%Prof/K) was not available for one industry.) Both the (Comp/L) and (Eng/L) variables are significant alone, the two have a correlation coefficient of .85, suggesting that multicollinearity is the reason they are insignificant when introduced into the regression simultaneously. Industries with substantial engineering and technical employment also have substantial numbers of computers, and vice versa. We try to ascertain an independent effect for computers by regressing the engineer variable on the computer measure and then introducing the residual (the portion of computer not linearly associated with the proportion of engineers and technical employees), into the regression. We are unable to find any significant effect of this residual on the multifactor growth rate independent of the proportion of engineering employment.

The bonus variable is significantly positive when all 39 industries are used in the analysis. However, this finding was not robust. In addition to the full sample we estimate the model for three subsets of the data; with three main outliers removed based on an influence statistic, with the six industries which have substantial differences between the constrained and unconstrained capital share estimates deleted; and for manufacturing only.

Table 4 provides the regressions based on the dropping the three observations with an influence statistic outside an acceptable range.[15] The bonus variable is either insignificant or significantly associated with decreases in multifactor productivity change. Moreover, the negative coefficient is also found when we use the percentage change in the bonus/labor ratio measured over the 1980-84 period rather than the 1980-85 period in an attempt to introduce a lag in the relationship because of the causality problem mentioned above.

The coefficient for the retained profit variable is generally positive, although its significance often declines when other variables are included in the regression. In particular, for the smaller samples this variable is insignificant after accounting for (ENG/L). This appears to result from multi-collinearity. For the restricted samples the correlation between retained profits and engineer and technical employment is quite high.

[15]The absolute values of the R Student statistic for the Prepared Feeds, Log Processing, and Electric, Steam and Hot Water industries are greater than 2. For details on this test, see Belsley, D.M., Kuan, E. and Welsch, R.E. (1980).

Table 4. Sources of Multifactor Productivity Growth,
Dependent Variable: Multifactor Productivity Growth Rate, 1980-85

Independent Variables

		Constant	(ENG/L)	(%PROF/K)	(%B/L)	(COMP/L)	$\bar{R}^2$
1.	N=39	-.080**	1.089**				.15
		(2.76)	(2.76)				
2.	N=38	-.062**		0.015*			.10
		(4.17)		(2.28)			
3.	N=39	-.096**			.091**		.18
		(4.05)			(3.08)		
4.	N=39	-.058**				29.716*	.11
		(3.61)				(2.35)	
5.	N=38	-.067*	1.126**	0.007	-.049		.25
		(2.13)	(2.99)	(1.00)	(1.03)		
6.	N=36	-.103**	1.046**	.015*			.50
		(8.05)	(3.75)	(2.17)			
7.	N=36	.072**	1.028**	.019**	-.082**		.57
		(4.43)	(4.61)	(2.95)	(2.73)		

*Denotes "significant" at the 5-percent level.

**Denotes "significant" at the 1-percent level.

VI. Concluding Comments

Our results suggest that enterprises which employ more technical employees are most likely to obtain increases in multifactor productivity growth. In addition, we find some evidence that retained profits, which we took as a measure of the surplus that an enterprise is allowed to keep for its own use, is positively correlated with multifactor productivity growth. Bonus payments to labor do not appear to reflect observed gains in multifactor productivity growth rates although the result is not robust. However, it is possible that the regression results arise because bonus payments are made for reasons other than increased productivity.

We also find substantially better productivity performance by collective and other nonstate enterprises relative to state-owned enterprises in the 1980-85 period. This conclusion is based on a comparison of estimates of multifactor productivity growth among the various ownership systems of the Chinese economy (state, collective, and other) at the aggregate level. Thus, the evidence suggests that collective and other nonstate enterprises are able to increase their productivity in the era of economic reforms far better than have state-owned enterprises.

Finally, we emphasize a point made earlier. The lack of information on the relationship of labor compensation and the allocations of capital and other inputs to production in The Peoples Republic of China makes it difficult to estimate the sources of productivity growth. We believe our estimates of capital shares are overstated, though the bias appears not to vary much over the time period we examine. This constancy of the bias enables us to draw some conclusions about the trend of productivity despite the bias in the estimated capital share. However, to really address this issue is beyond the scope of this paper. Analysis at a more disaggregate level and use of provincial data from China's industrial census should help in this regard.

In a similar vein, further research on pricing and capital valuation is needed. International price comparisons, such as those undertaken by the United Nations International Comparisons Project (ICP), might be used to revalue capital and output or at least provide the basis for assessing the bias in the factor share estimates. Finally, we point out that the concept of productivity is complex, especially if multiple inputs are considered. The multifactor approach taken in this paper provides a way to decompose labor productivity growth into growth in efficiency and capital intensity. Compared to simple measures of labor productivity, this alternative provides new and useful information on the nature and causes of growth and technical change in post-reform China.

APPENDIX: DATA AND MEASUREMENT

The estimates and results reported in this paper are derived from data for the years 1980, 1984, and 1985 reported in The National Industrial Census of China (1988). The data cover 39 industries, 8 in the mining and extractive sector, 2 in energy production, and 29 in manufacturing. Coverage is restricted to large and medium sized enterprises which account for 50 percent of output in the industries examined.

Data for each industry include net and gross values of output, net and gross values of fixed assets used in production and housing, education, and related labor services. The data also include nominal values of materials consumed in production and total numbers of employees. The labor information is further broken down into categories such as management, and technical and scientific employees (available for 1985 only). Several financial variables such as wages, expenditures for the security and welfare of employees, profits, taxes, and a measure of the earnings retained by the enterprise are also provided. These data enable us to develop an output deflator (gross output in current prices divided by gross output in constant prices for each branch) and a separate deflator for capital services (weighted average of the deflators derived for the machinery and equipment sectors). We are also able to derive a measure of capital services by using depreciation rates available implicitly in the reported data.

The _National Industrial Census_ does not provide detailed ownership data by industry. This is unfortunate since, as noted earlier, the state-owned and collective enterprises represent different organization structures and faced different operating rules in the 1981-84 period. (State-owned firms have greater access to low-cost inputs allocated under the state plan, which improves their profit-ability vis-a-vis collective firms.) Moreover, the aggregate data suggest that multifactor productivity growth differs between these types of enterprises in the period under examination.

Recent literature focuses on various difficulties in using Chinese data for industrial productivity analysis. Three critical limitations are emphasized by most commentators; (1) many prices in China continue to be administered, (2) input data include resources used for nonproduction related services, and (3) capital measured in terms of original cost is problematic given dramatic changes over time in capital prices and quality. Each of these issues is considered in our discussion of the derived variables necessary for estimating $\hat{a}(t)$ in equation (4).

Output

The measure of real output reported is based on average 1980 prices from lists issued by the State Statistical Bureau (SSB, 1988). Thus, the deflator is based on administered prices. Nominal output is valued according to actual prices observed during each year. This means that for 1980, the base year, the constant and nominal values of output differ. While the average ratio of nominal to real output across the spectrum of industries in 1980 is very close to 1.00, .992, the minimum value is .910 and the maximum value is 1.221. This large variation led us to normalize the data by setting the 1980 price index at 1.00 and then readjust the real output values so that the 1980 deflator is the basis for determining the constant Rmb output in each year. This procedure made little difference in the structure of the series calculated for $\hat{a}(t)$.

There remains a question regarding the extent to which administered pricing is used in different industries. As a practical matter we have no quantitative way to adjust for this factor. However, as discussed in the text, it is clear that for many industries in our sample the productivity estimates are strongly affected by pricing policies. Thus, most of our empirical efforts center on a subset of the industries.

Capital

There are two problems with the capital stock data. First, total fixed assets are calculated by adding each year's investment, valued at current prices, to the sum of assets from previous years (less depreciation) which are valued at original purchase prices. This means that price increases (decreases) in capital goods bias the measured capital stock upward (downward).

In a recent paper Jefferson (1989) argues, citing Rawski (1986), that rapid price increases beginning in 1981 indicate that much of the observed investment increases in the 1980s could be an illusion due to inflation. He uses a measure of the age of the capital stock as a proxy deflator on the grounds that the greater the proportion of new capital in the total capital stock, the greater the inflation bias in the data. However, use of the proxy did not alter his basic results. Jefferson attributed this lack of effect to the possibility that newer capital represented more efficient vintages than older capital. He argues that this offsets the inflation bias. While we do not try to adjust directly for age of capital stock, an age variable is not significant in explaining inter-industry multifactor productivity differences.

As a practical matter we develop an output weighted price index using prices of capital and machinery goods industries as a deflator for the capital stock. The deflator is calculated by dividing gross output for these branches in current prices by their gross output in constant prices. This is a more direct approach than the proxy used by Jefferson. What is surprising is that based on our price index, inflation in investment goods is less than that observed for consumption goods like food and beverages. Moreover, the data show little inflation in the 1980-84 period.

The second issue is the appropriate measure of production capital. Enterprises in China, unlike much of the rest of the world, supply medical, education and related services directly to their workers. To develop a measure of production efficiency, these "auxiliary" services are separated from the direct production input.

The SSB provides an explicit measure of capital for production use as distinct from capital used for health, education, recreation, and other auxiliary services. However, we are only able to obtain a depreciation rate for total assets. While we use this value for both sets of assets, we suspect it has some downward bias as applied to productive capital. This type of capital is primarily buildings and structures with relatively long lives compared to machinery which forms a large component of production capital. For international comparisons of productive efficiency this separation is likely to be necessary. For example, since the auxiliary services supplied are a necessary part of doing business in China, it is important to include the total cost of producing the auxiliary services in assessing efficiency. Moreover, if the primary difference between collective and state-owned enterprises is their auxiliary services then they need to include in comparing the alternative organizational forms.

Labor

The number of employees includes all the employees paid by the enterprise -- not just those engaged in production. This means that total labor includes workers providing employee services (education, health care, and related activities) as well as production workers. Kuan, et al (1988) used the ratio of nonproduction assets to total assets to make a crude adjustment in total employment figures. This is unlikely to be an appropriate adjustment because it assumes that the production of services is as capital intensive as production across the spectrum of industrial activities.

As a test of the Kuan, et al procedure for estimating service employment, we compare the ratio of nonproduction assets to total assets with the ratio of service employment to total employment for 1985. We find that the means of the ratios are similar, .189 for the capital ratio and .163 for the labor ratio. However, the range of values is far less for the labor ratio, .212, than for the capital ratio, .339, and the simple correlation between the measures is only .16. Therefore we conclude that the ratio of nonproduction to total assets is not a good estimate of the proportion of factor payments obtained by production labor.

The number of service employees to total employment is only available in 1985. Therefore, we use this ratio to estimate the total production workers for 1980 and 1984 as well as 1985. This adjustment, however, adds little to the analysis of growth in labor, since it is the growth rate, not the number of employees which is included in the model. Thus, use of a constant proportion adjustment does not affect the measured growth rate in production labor. This adjustment is, however, important for the weights since they are measured in levels, not growth rates.

Weights

In this study we observe growth rates for the periods 1980-84 and 1984-85 for each industry. Therefore, it is not feasible to estimate the production function directly. In future work we plan to exploit regional data to obtain output elasticity estimates econometrically. Nonetheless, the econometric procedures are also not without problems. For example, the econometric approach requires an explicit model for the allocation of labor and capital demand in Chinese industries for appropriate statistical estimates. Thus, we take a somewhat eclectic view of the appropriate estimation procedures.

As a practical matter, lack of data obliges us to use calculated factor shares. For labor we include in the labor share direct and indirect compensation. Direct compensation is measured by wages. Indirect payments include welfare and security expenditures and an estimate of capital services calculated by depreciating nonproduction capital. As discussed above, we use the ratio of service employment to total employment for 1985 to adjust the total wages for both direct and indirect compensation so they only include estimated payments to production labor.

The estimated labor share appears low before this adjustment. However, when capital services obtained from housing and other nonproduction capital and payments for security and welfare are included, the calculated labor share is more in line with that obtained by Kuan et al (1988) on the basis of time series data. The share is also in line with that found by Jefferson (1989a). This is evidence that our procedures are reasonable.

We use two different procedures to obtain the estimates of capital share. The first assumes that the shares sum to 1.00 (constant returns to scale) and takes the capital share as 1.00 minus the calculated labor share. The second method drops the constant returns to scale assumption and calculates the capital share as the sum of profits and taxes divided by total output.

It is clear that calculating factor shares for capital as the sum of profits and taxes results in some upward bias. The crux of the problem is that a portion of taxes and profits ultimately returns to labor as employee benefits and indirect social services. For example, Tidrick and Byrd (1987) point out that Chinese enterprises often devote the lion's share of retained profits to increasing the bonuses and benefits of their employees. The use of profits and taxes to calculate capital share is further clouded because profits are a consequence of the administered pricing system instead of a true return to capital. Moreover, effective tax rates vary among enterprises based on their differential ability to persuade local authorities to increase their retained earnings.

To get a better feel for these issues, Table A1 provides comparisons of the capital shares in 1980, 1984, and 1985 for both estimation methods. Capital share obtained by subtracting the calculated labor share from 1.00, the constrained method, is labeled skc(t), where the (t) stands for the appropriate year. The label sku(t) stands for the comparable figure obtained by taking total profits plus taxes as a proportion of total output, the unconstrained method.

Several interesting observations are drawn from Table A1. First, the correspondence between the shares obtained by the constrained and unconstrained methods is quite close except for the first 11 industries, all of which are in the nonmanufacturing sector. We include the prepared feeds industry which has only two reporting enterprises in nonmanufacturing because it is closely allied to agriculture. It also has other features which are not typical of the rest of manufacturing. (The ratio of nominal to real output, both measured in 1980 prices is 1.22, substantially greater than the next highest ratio of 1.06. In addition, profits and taxes are zero in 1980.)

The differences in the two sets of estimates of w_k for nonmanufacturing suggest either that this sector is not characterized by constant returns for scale, or that tax/subsidy/pricing policies affect the calculated capital shares. This suggests that the multifactor productivity decomposition may not work well in nonmanufacturing.

Second, for both the manufacturing and nonmanufacturing sectors the two methods for calculating w_k give consistent results across time. Table A2 provides correlation coefficients of skc(t) and sku(t) across time. The lowest year to year correlation is .75 for the constrained estimator of w_k between 1980-85. A similar value, .76, is observed as the lowest correlation for the unconstrained estimator over the 1980-85 period. This suggests that the estimators are relatively stable across time for both manufacturing and nonmanufacturing. In turn, even with the expected upward bias in the level of the capital share, conclusions based on trends in multifactor productivity are likely to be reasonable.

Finally, we note that the average share of capital falls by about 4 percentage points in manufacturing between 1980 and 1985 based on both the constrained and unconstrained shares. However, for nonmanufacturing, the constrained share shows a stable average share, but the unconstrained share shows a large drop. This last result points to a problem with the unconstrained estimator in nonmanufacturing. Despite a high correlation over time, the individual values show large variances and, as Table A2 points out, the correlation between skc(t) and sku(t) is very low for nonmanufacturing. Mindful of these shortcomings we use the constrained shares in our calculations of total factor productivity.

Table A1. Constrained and Unconstrained Capital Shares

Nonmanufacturing

		SKC80	SKC84	SKC85	SKU80	SKU84	SKU85
1	Coal	.40984	.32369	.21837	.32506	.15138	.02323
2	Pet.&Gas	.93101	.92880	.92674	.91354	.51367	.44355
3	Ferrous	.57954	.59642	.57118	.53951	.56896	.61694
4	Non-Ferr	.47426	.39541	.48938	.46753	.38577	.37461
5	Bldg.Mat	.50553	.47290	.37861	.51058	.58604	.39692
6	Salt	.87101	.84347	.81889	.16877	.21394	.15819
7	Logging	.52994	.58579	.59005	.34986	.36493	.33503
8	Water	.79312	.74941	.72471	.81886	.80524	.80618
9	Feeds	.53294	.87448	.85336	.73333	.90647	1.00000
10	Elect	.94394	.92391	.92199	.74910	.70546	.68260
11	Coke	.67622	.62106	.67782	.74860	.84063	.80403

Manufacturing

		SKC80	SKC84	SKC85	SKU80	SKU84	SKU85
12	Food	.81958	.75999	.75226	.77415	.68391	.71583
13	Beverage	.86842	.86765	.85742	.85231	.83840	.79716
14	Tobacco	.97880	.97901	.97689	.96815	.85514	.96064
15	Textiles	.85526	.73805	.72775	.85540	.68892	.69042
16	Clothing	.69714	.67404	.64133	.71423	.72152	.69306
17	Leather	.68230	.61578	.63548	.67969	.59711	.61007
18	Woodprod	.84876	.63280	.60335	.80826	.67904	.67268
19	Furn	.70037	.66597	.66638	.69465	.59116	.62797
20	Paper	.81271	.77159	.78494	.79126	.72434	.73900
21	Printing	.68042	.75096	.72181	.74532	.66252	.78652
22	Culture	.88212	.87732	.85947	.90583	.92140	.90678
23	Artcraft	.71394	.56959	.59022	.64548	.47787	.49596
24	Pet.Ref	.96891	.96163	.96010	.93695	.92800	.91279
25	Chemical	.85366	.83454	.82204	.82074	.81590	.79569
26	Medicine	.86788	.82965	.80575	.82201	.73600	.71241
27	Fibres	.88613	.87065	.88006	.90546	.82339	.84721
28	Rubber	.90774	.88344	.87573	.84593	.83589	.81304
29	Plastics	.84096	.82159	.80954	.80912	.72725	.74503
30	Nonmetal	.70474	.69183	.71282	.73580	.72065	.69627
31	Ferrous	.79648	.78745	.78469	.78019	.80610	.80652
32	Non-Ferr	.79862	.73389	.75068	.74021	.71655	.69290
33	MetalWk	.73957	.69603	.72492	.76115	.70190	.72296
34	Eng.Eq	.64467	.62495	.66283	.60516	.61558	.61089
35	Trans.Eq	.62606	.64061	.70972	.59750	.63352	.65447
36	Elec.Eq	.79354	.77491	.79586	.73233	.73979	.73414
37	Com.Eq	.65661	.75661	.78025	.57721	.70092	.68555
38	Instru	.65875	.64277	.65300	.62830	.62241	.59286
39	Other	.83959	.73658	.67922	.97502	.79271	.79782

Means

Nonmanufacturing	.6589	.5750	.6650	.5493	.6819	.5128
Manufacturing	.7901	.7753	.7568	.7271	.7580	.7358
All	.7531	.7188	.7309	.6769	.7281	.6707

Table A2. Correlations of Capital Shares
by Estimation Method and Time

Variables	Year	Manufacturing (N=28)	Nonmanufacturing (N=11)
SKC(t)	80&84	.83	.84
	80&85	.75	.83
	84&85	.86	.97
SKU(t)	80&84	.78	.80
	80&85	.82	.76
	84&85	.93	.97
SKC(t)	1980	.91	.43
and	1982	.89	.45
SKU(t)	1985	.86	.55

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